FILTER AKTIF

Low Pass Filter
(LPF)

High Pass Filter
(HPF)

Band Pass Filter
(BPF)

Band Stop Filter
(BSF)

Pengertian satuan "DESIBEL" (*DECIBEL*) (*dB*)

Desibel yang sering disingkat dengan **"dB"** ini dapat diartikan sebagai **"Perbandingan antara dua besaran dalam skala Logaritma".**

Dalam perhitungan Desibel, **penguatan** atau ***Gain*** suatu sinyal akan ditandai dengan tanda **"+"** (positif) sedangkan **pelemahan** atau ***Loss*** akan ditandai dengan tanda **"-"** (negatif). Dengan demikian, jika sinyal Output **+**6dB dari sinyal Input maka hal ini menandakan terjadinya **penguatan** Output sebanyak 6dB dari sinyal Input. Sebaliknya jika sinyal Output -

Rumus-rumus Desibel

Rumus Penguatan Daya

Penguatan Daya (dB) = 10 log (P_{out} / P_{in})

Rumus Penguatan Tegangan

Penguatan Tegangan (dB) = 20 log (V_{out} / V_{in})

Rumus Penguatan Arus

Penguatan Arus (dB) = 20 log (I_{out} /I_{in})

Contoh

Penguatan tegangan suatu filter :

= 0,707

Penguatan Tegangan (dB) = 20 log

= 20 log = -3

dB

Pelemahan

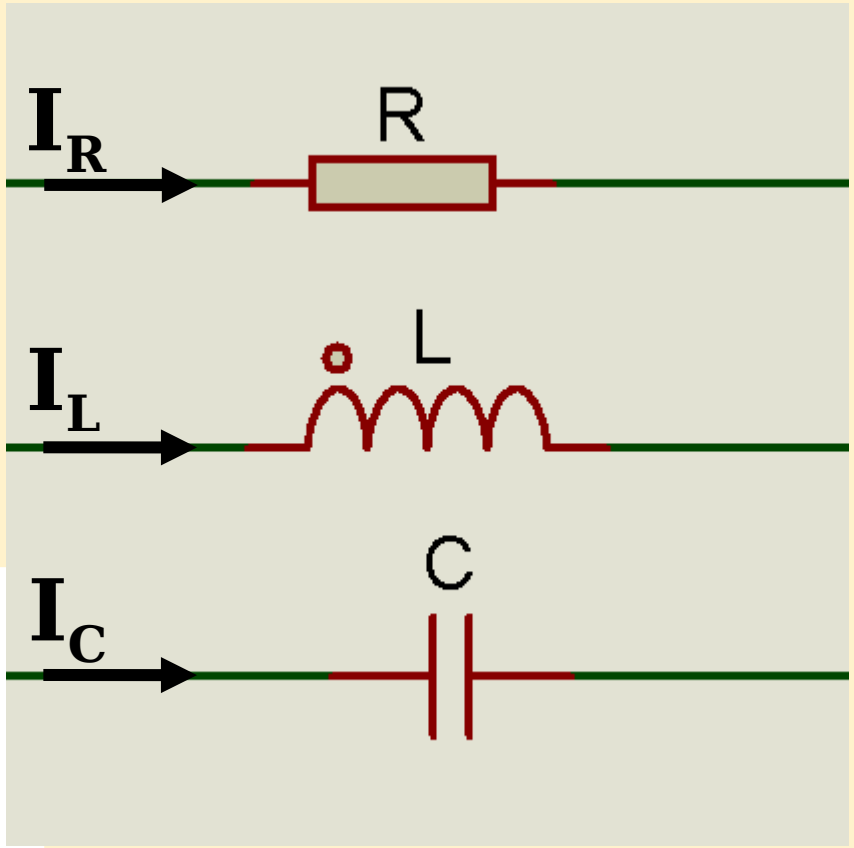
Tanggapan Frekuensi pada Komponen Pasif

$Z_R =$

$Z_L =$

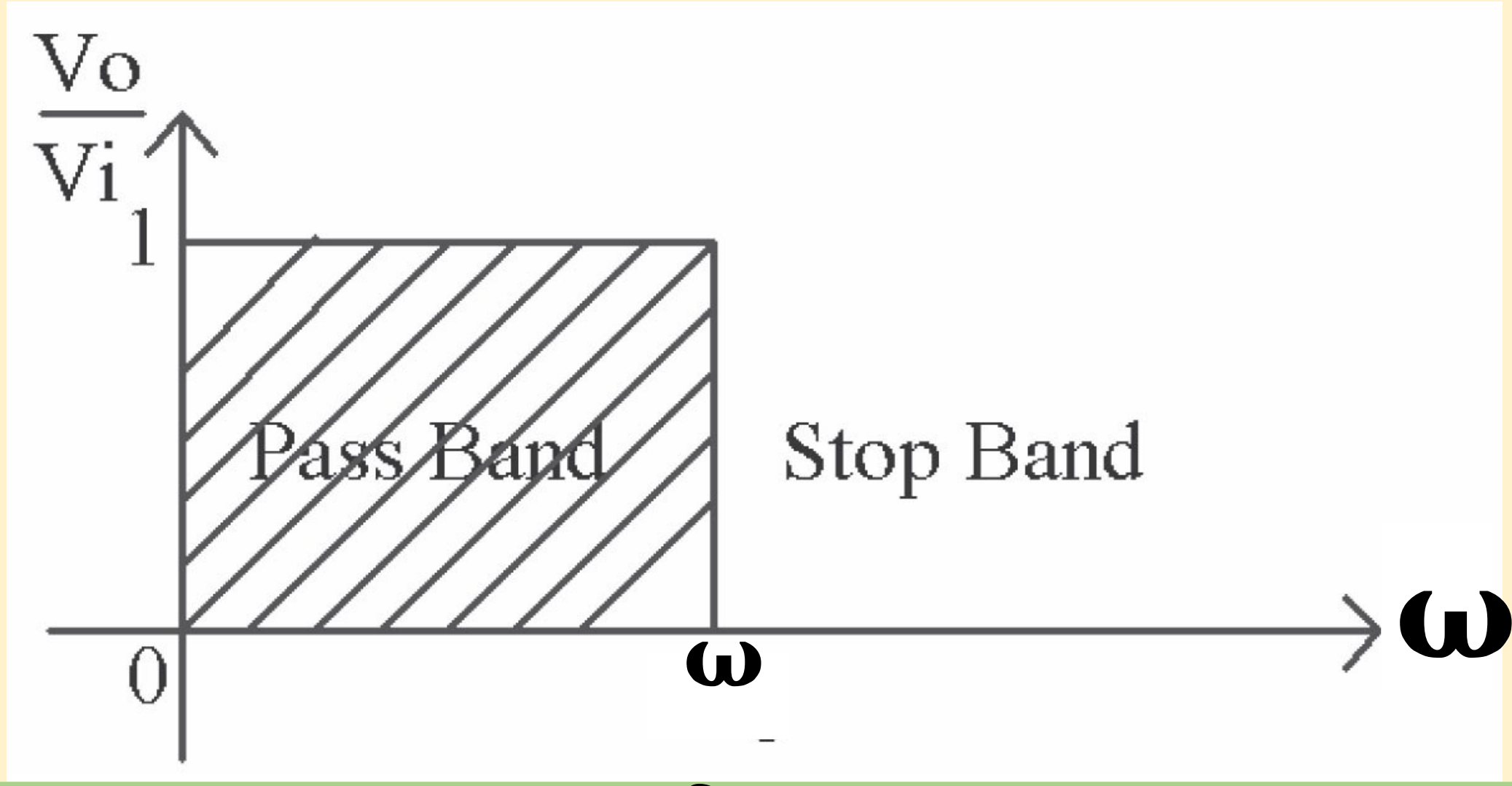
$Z_C =$

$1/j\omega C$

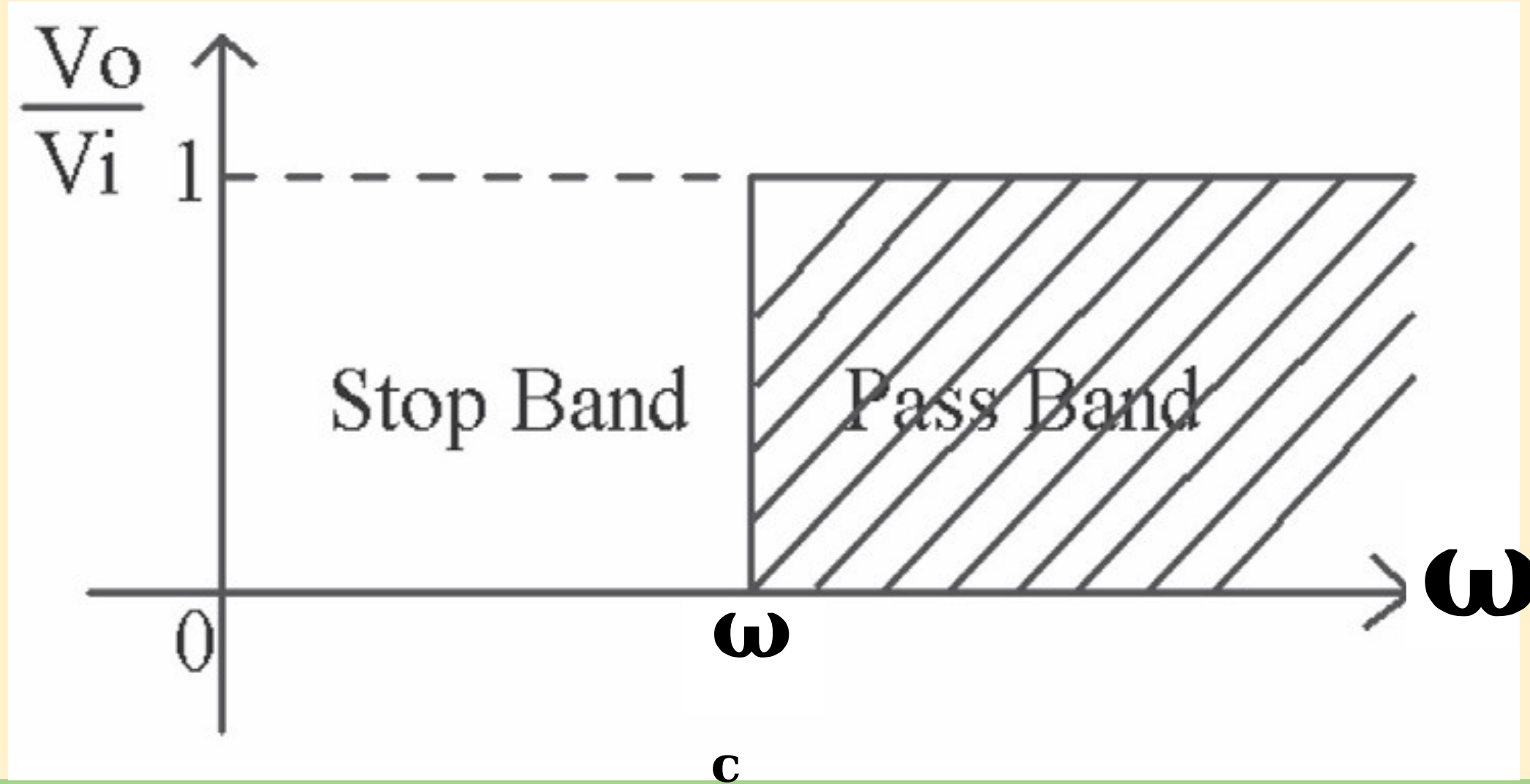


$\omega = 2\pi$

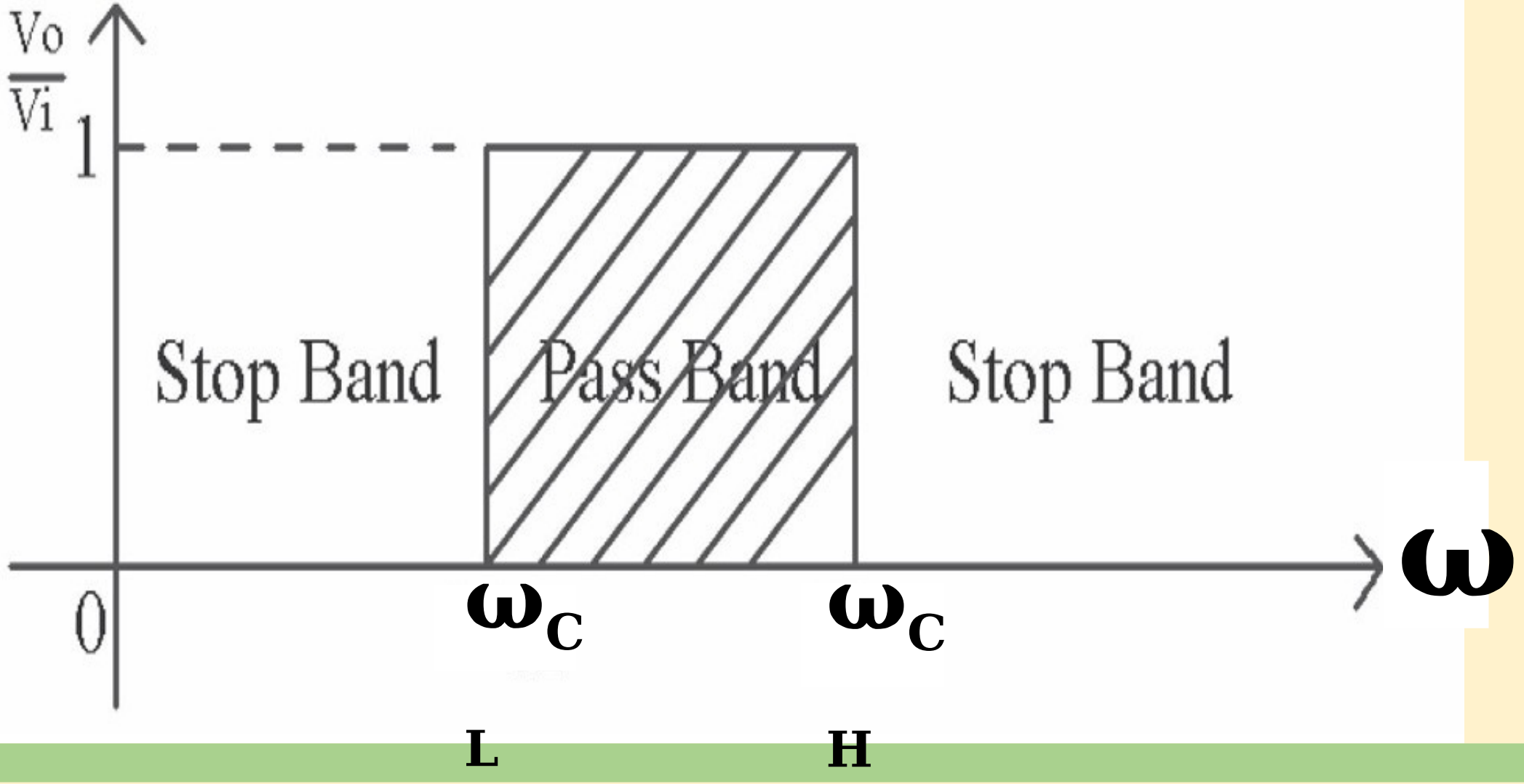
Tanggapan Frekuensi pada LPF Ideal



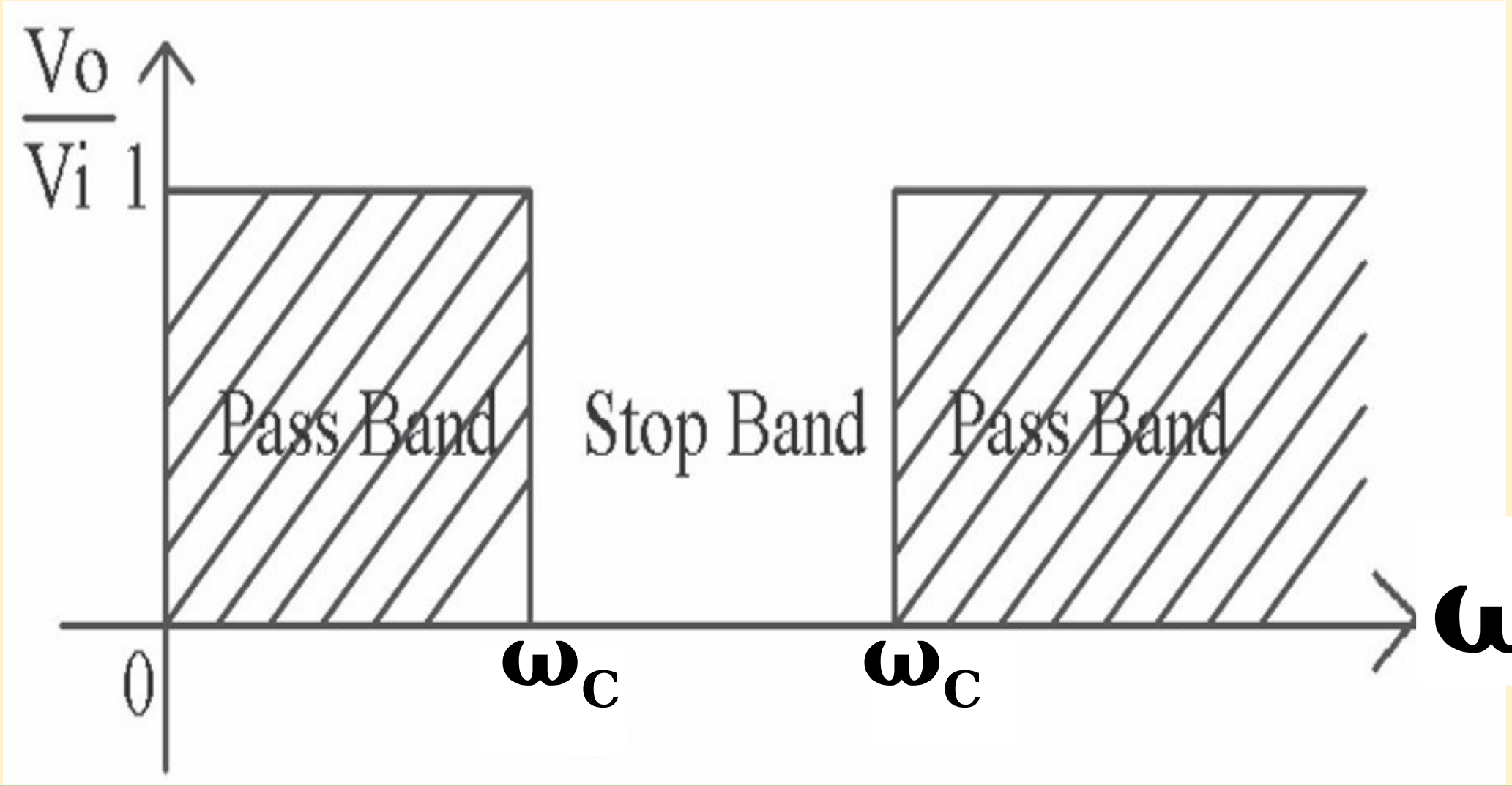
Tanggapan Frekuensi pada HPF Ideal



Tanggapan Frekuensi pada BPF Ideal



Tanggapan Frekuensi pada BSF Ideal



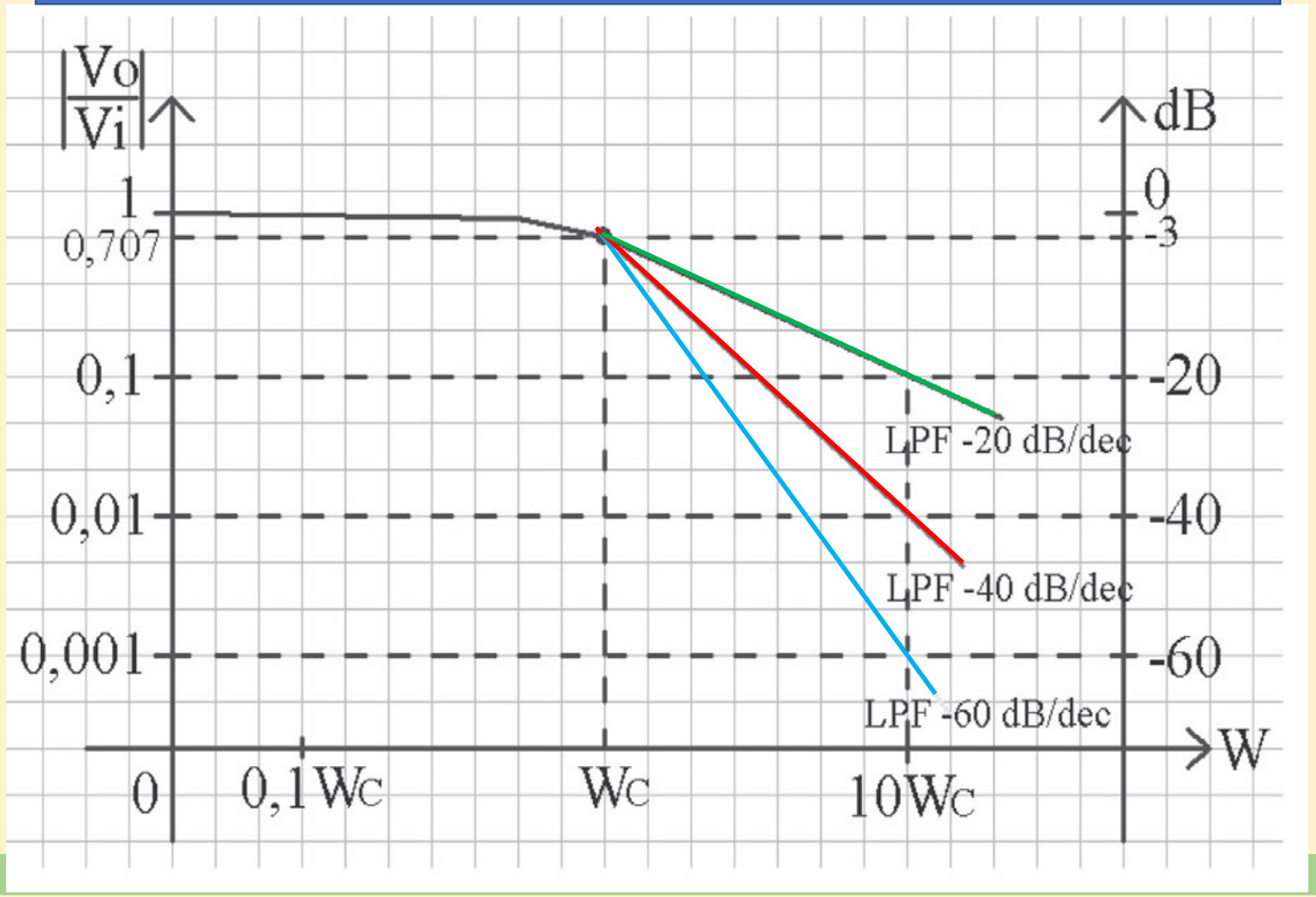
Low Pass Filter
(LPF)

LPF -20 dB/dec adalah LPF yang penguatannya turun (pelemahan) sebesar 20 dB apabila frekuensinya naik sebesar 10 kali atau satu decade. Pada saat frekuensi sinyal input sama dengan frekuensi *cut-off* (ω_c) maka penguatannya sama dengan (1/) atau 0,707 dan sudut phasenya sebesar -45^o.

LPF -40 dB/dec adalah LPF yang penguatannya turun (pelemahan) sebesar 40 dB apabila frekuensinya naik sebesar 10 kali atau satu decade. Pada saat frekuensi sinyal input sama dengan frekuensi *cut-off* (ω_c) maka penguatannya sama dengan (1/) atau 0,707 dan sudut phasenya sebesar -90^o.

LPF -60 dB/dec adalah LPF yang penguatannya turun (pelemahan) sebesar 60 dB apabila frekuensinya naik sebesar 10 kali atau satu decade. Pada saat frekuensi sinyal input sama dengan frekuensi *cut-off* (ω_c) maka penguatannya sama dengan (1/) atau 0,707 dan sudut phasenya sebesar -135^o.

Tanggapan Frekuensi pada LPF Real

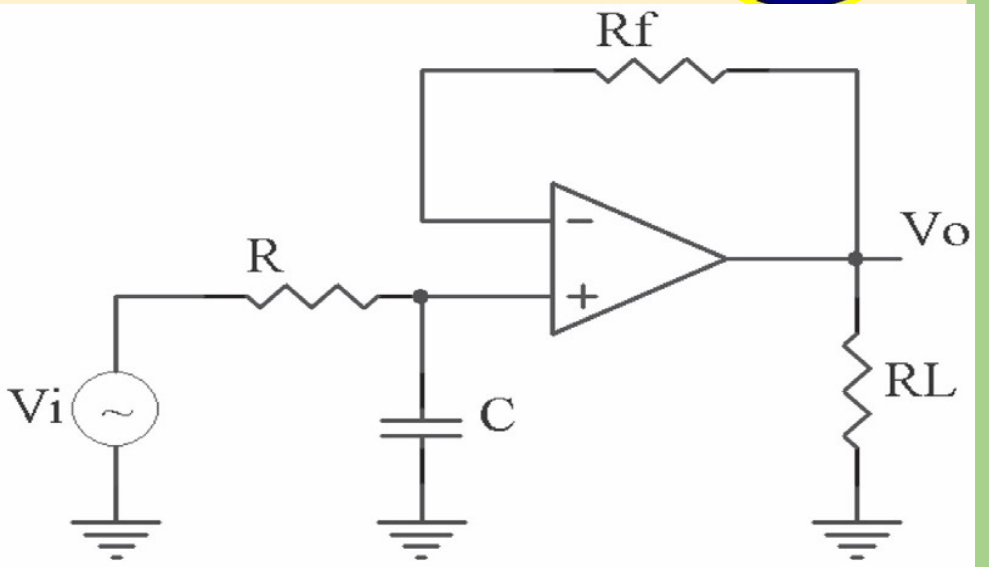


Rangkaian LPF -20 dB

$$Vo = \frac{Zc}{R + Zc}.Vi$$

$$Vo = \frac{\frac{1}{j\omega.C}}{R + \frac{1}{j\omega.C}}.Vi$$

$$\frac{Vo}{Vi} = \frac{1}{1 + j\omega.C.R} \quad \text{..... (6.3)}$$



Gambar 6.1 *Rangkaian LPF -20 dB/dec*

Pada LPF -20 dB/dec bahwa pada $\omega = \omega_c$ maka nilai dan sudut phasenya sama dengan $\left|\frac{Vo}{Vi}\right| = \frac{1}{\sqrt{2}} = 0{,}707$

Supaya menghasilkan nilai seperti itu maka nilai pada penyebut pada persamaan (6.3) adalah $|1 + j\omega.C.R| = \sqrt{2}$

sehingga $\omega_c.C.R = 1$ atau $\omega_c = \frac{1}{C.R}$

$$\omega_c = 2\pi f_c$$

$$\omega_c = 2\pi . f_c$$

$$\frac{\square\square}{\square\square} = \frac{1}{1 + \square\square . \square . \square} = \frac{1}{1 + \square\left(\frac{\omega}{\omega\square}\right)}$$

Tabel 6.1 *Nilai penguatan dan sudut phase LPF -20 dB/dec*

No.	Frekuensi (ω)	Penguatan $\left\|\frac{Vo}{Vi}\right\|$	Sudut phase (θ)
1	$0{,}1\omega_c$	0,9950371902	–5,71°
2	$0{,}25\omega_c$	0,9701425001	–14,04°
3	$0{,}5\omega_c$	0,8944271909	–26,56°
4	ω_c	$\frac{1}{\sqrt{2}}$ atau 0,707	–45°
5	$2\ \omega_c$	0,4472135955	–63,43°
6	$4\ \omega_c$	0,2425356250	–75,96°
7	$10\ \omega_c$	0,0995037190	–84,29°

Contoh 6.1

Hitunglah frekuensi *cut-off* (ω_c) pada Gambar 6.1 apabila nilai R=10K, C= 10 nF, Rf= 100 K, RL= 10 K! Apabila Vi = $100\sin(\omega.t+30^0)mV$, hitunglah Vo pada frekuensi 1 Krad/s, 5 Krad/s, 10 Krad/s, 20 Krad/s, 100 Krad/s!

Penyelesaian:

$$\omega_c = 2\pi f_c$$

$$\omega_c = \frac{1}{10^{-8}.10^4} = 10^4 \text{ rad/s} = 10 \text{ Krad/s}$$

Untuk $\omega = 1$Krad/s , $\omega = 0{,}1\,\omega_c$

$$\left|\frac{Vo}{Vi}\right| = \frac{1}{1+j\left(\frac{\omega}{\omega_c}\right)} = \frac{1}{1+j\left(\frac{1}{10}\right)} = \frac{1}{1+j0{,}1} = \frac{1}{\sqrt{1+0{,}1^2}} = 0{,}995$$

$$\theta = \frac{0^\circ}{tg^{-1}\left(\frac{0{,}1}{1}\right)} = \frac{0^\circ}{5{,}71^\circ} = 0^\circ - 5{,}71^\circ = -5{,}71^\circ$$

Vo =

Untuk $\omega = 5\text{Krad/s}$, $\omega = 0{,}5\,\omega_c$

$$\left|\frac{Vo}{Vi}\right| = \frac{1}{1+j\left(\frac{\omega}{\omega_c}\right)} = \frac{1}{1+j\left(\frac{5}{10}\right)} = \frac{1}{1+j0{,}5} = \frac{1}{\sqrt{1+0{,}5^2}} = 0{,}894$$

$$\theta = \frac{0°}{tg^{-1}\left(\frac{0{,}5}{1}\right)} = \frac{0°}{26{,}56°} = 0° - 26{,}56° = -26{,}56°$$

$Vo = (0{,}894).100\sin(5.10^3 t + 30^o + \Theta) = 89{,}4\sin(5.10^3 . t + 3{,}44^o)\text{mV}$

$\omega = \omega_c$

$$\left|\frac{Vo}{Vi}\right| = \frac{1}{1+j\left(\frac{\omega}{\omega_c}\right)} = \frac{1}{1+j\left(\frac{10}{10}\right)} = \frac{1}{1+j1} = \frac{1}{\sqrt{1+1^2}} = 0{,}707$$

$$\theta = \frac{0°}{tg^{-1}\left(\frac{1}{1}\right)} = \frac{0°}{45°} = 0° - 45° = -45°$$

Vo =

Untuk $\omega = 20\text{Krad/s}$, $\omega = 2\,\omega_c$

$$\left|\frac{Vo}{Vi}\right| = \frac{1}{1+j\left(\frac{\omega}{\omega_c}\right)} = \frac{1}{1+j\left(\frac{20}{10}\right)} = \frac{1}{1+j2} = \frac{1}{\sqrt{1+2^2}} = 0{,}447$$

$$\theta = \frac{0°}{tg^{-1}\left(\frac{2}{1}\right)} = \frac{0°}{63{,}43°} = 0° - 63{,}43° = -63{,}43°$$

Vo = (0,447).100sin(2.10⁴.t+30º+Θ)=44,7sin(2.10⁴.t -33,43º)mV

$\omega = 10\,\omega_c$

$$\left|\frac{Vo}{Vi}\right| = \frac{1}{1+j\left(\frac{\omega}{\omega_c}\right)} = \frac{1}{1+j\left(\frac{100}{10}\right)} = \frac{1}{1+j10} = \frac{1}{\sqrt{1+10^2}} = 0{,}099$$

$$\theta = \frac{0°}{tg^{-1}\left(\frac{10}{1}\right)} = \frac{0°}{84{,}29°} = 0° - 84{,}29° = -84{,}29°$$

Vo = (0,099).100sin(10⁵.t+30º+Θ)=9,9sin(10⁵.t -54,29º)mV

Langkah-langkah perancangan LPF - 20 dB/decade

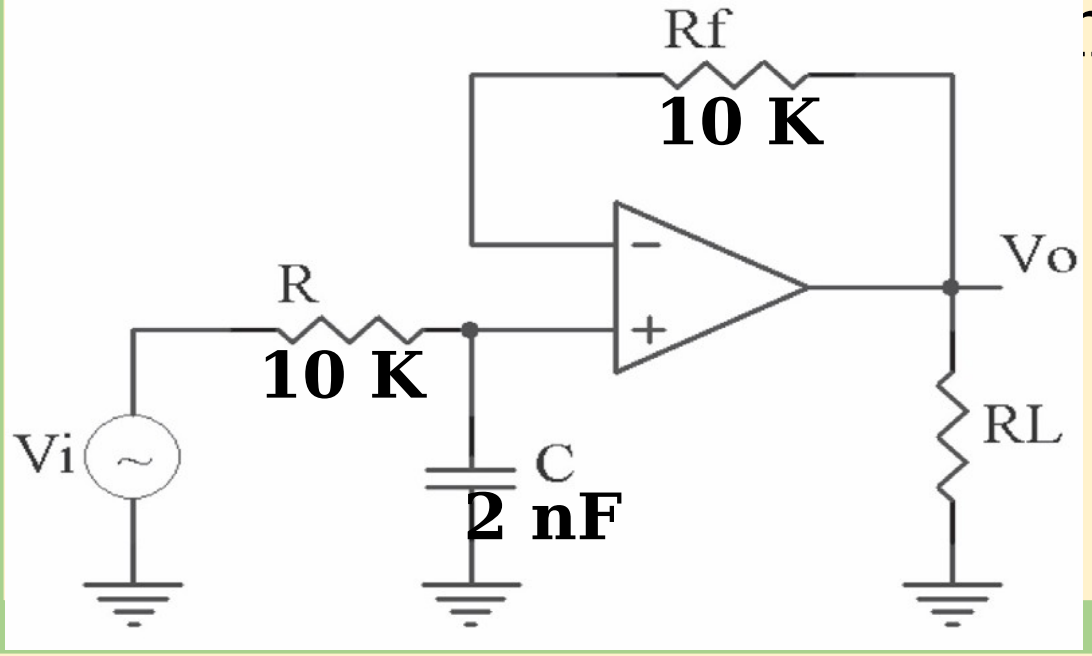
1. Pilihlah frekuensi *cut-off* () atau $\boldsymbol{f_c}$,
2. Pilihlah **R** antara 10 K dan 100 K,
3. Hitunglah **C** dengan rumus **C=**
4. Pilihlah **Rf = R**

Contoh 6.2

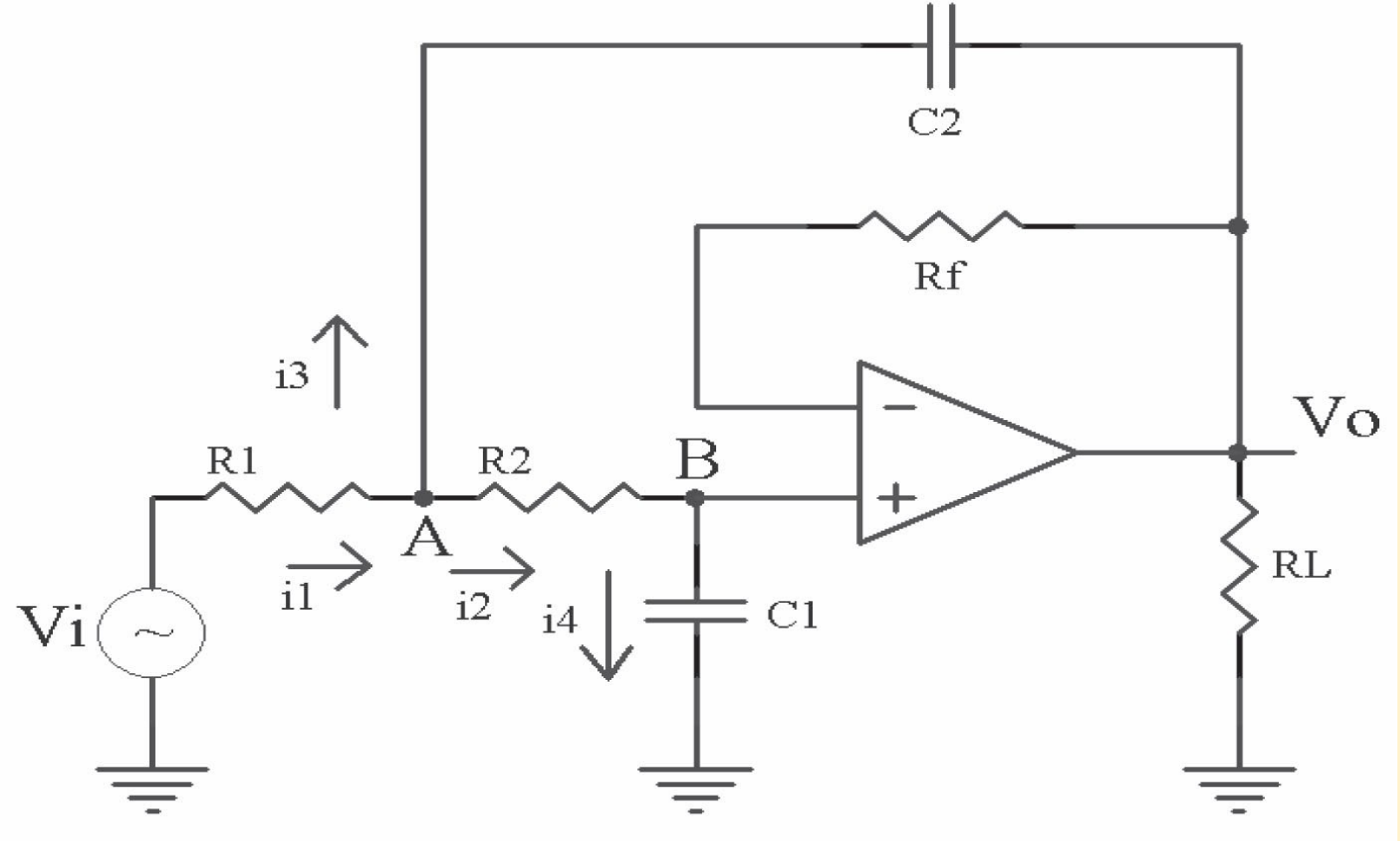
Rancanglah LPF -20 dB/dec dengan = 50 krad/det !

Penyelesaian:

1. Pilihlah frekuensi *cut-off* = 50 krad/det
2. Pilihlah **Rf = R =** 10 K,
3. Hitunglah C dengan rumus **C= = = 2 nF**



Rangkaian LPF - 40 dB

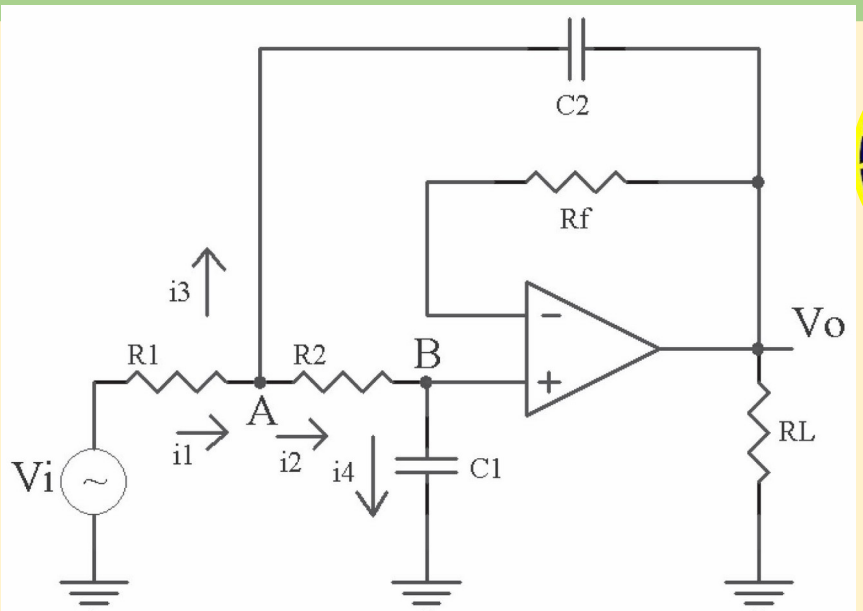


Gambar 6.2 *Rangkaian LPF -40 dB/decade*

Pada titik A adalah $I1 = I2 + I3$

Pada titik B adalah $I2 = I4$

Tegangan **Vo** sama dengan tegangan **VB** sehingga :



$$I4 = \frac{VB}{\frac{1}{j\omega.C1}} = j\omega.C1.VB = j\omega.C1.Vo$$

$$I2 = \frac{VA - VB}{R2} = \frac{VA - Vo}{R2}$$

$$I2 = I4 = j\omega.C1.Vo$$

$$\frac{VA - Vo}{R2} = j\omega.C1.Vo$$

$$VA = Vo + j\omega.C1.R2.Vo$$

$$I3 = \frac{VA - Vo}{\frac{1}{j\omega.C2}} = (VA - Vo)\,j\omega.C2$$

$$I3 = (Vo + j\omega.C1.R2.Vo - Vo)\,j\omega.C2$$

$$I3 = -\omega^2.C1.C2.R2.Vo$$

$$I1 = \frac{Vi - VA}{R1}$$

$$I1 = I2 + I3$$

$$\frac{Vi - VA}{R1} = j\omega.C1.Vo + \left(-\omega^2.C1.C2.R2.Vo\right)$$

$$Vi = VA + j\omega.C1.R1.Vo - \omega^2.C1.C2.R1.R2.Vo$$

$$Vi = Vo + j\omega.C1.R2.Vo + j\omega.C1.R1.Vo - \omega^2.C1.C2.R1.R2.Vo$$

$$Vi = Vo\left\{1 - \omega^2.C1.C2.R1.R2 + j\omega.C1(R1+R2)\right\}$$

$$\frac{Vo}{Vi} = \frac{1}{1 - \omega^2.C1.C2.R1.R2 + j\omega.C1(R1+R2)}$$

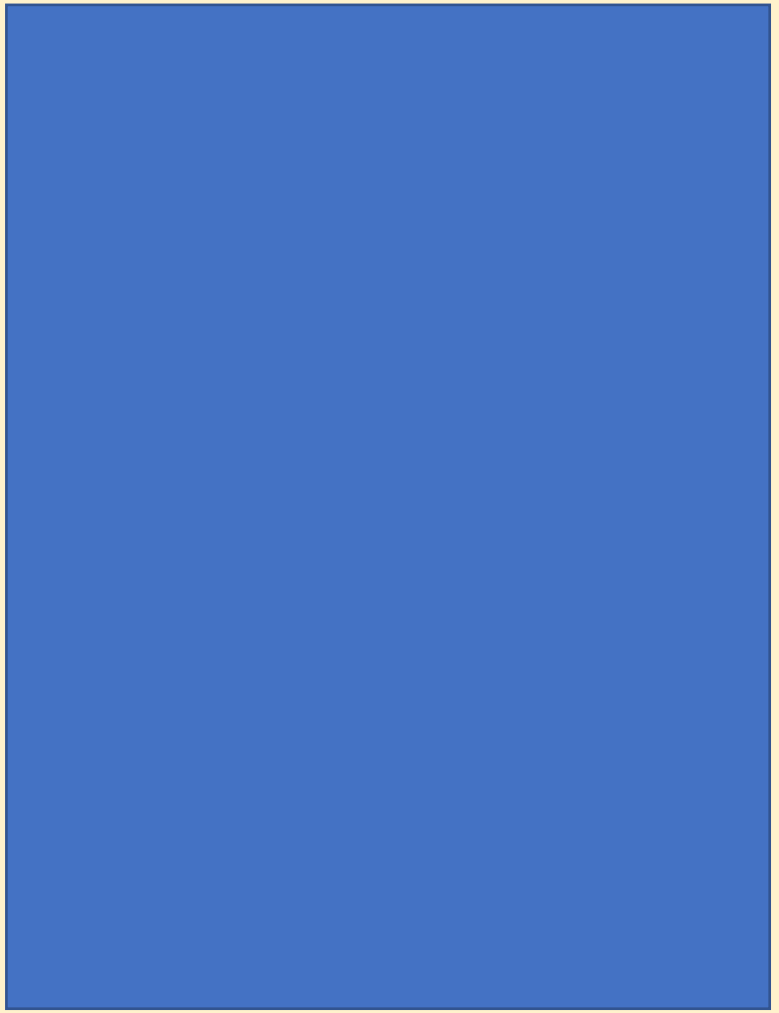
=

Apabila nilai resistor dibuat **R1 = R2 = R** dan nilai kapasitor dibuat **C2 = 2.C1** maka

=

Supaya menghasilkan sudut phase $+90^{o}$ maka nilai **= 0**

=

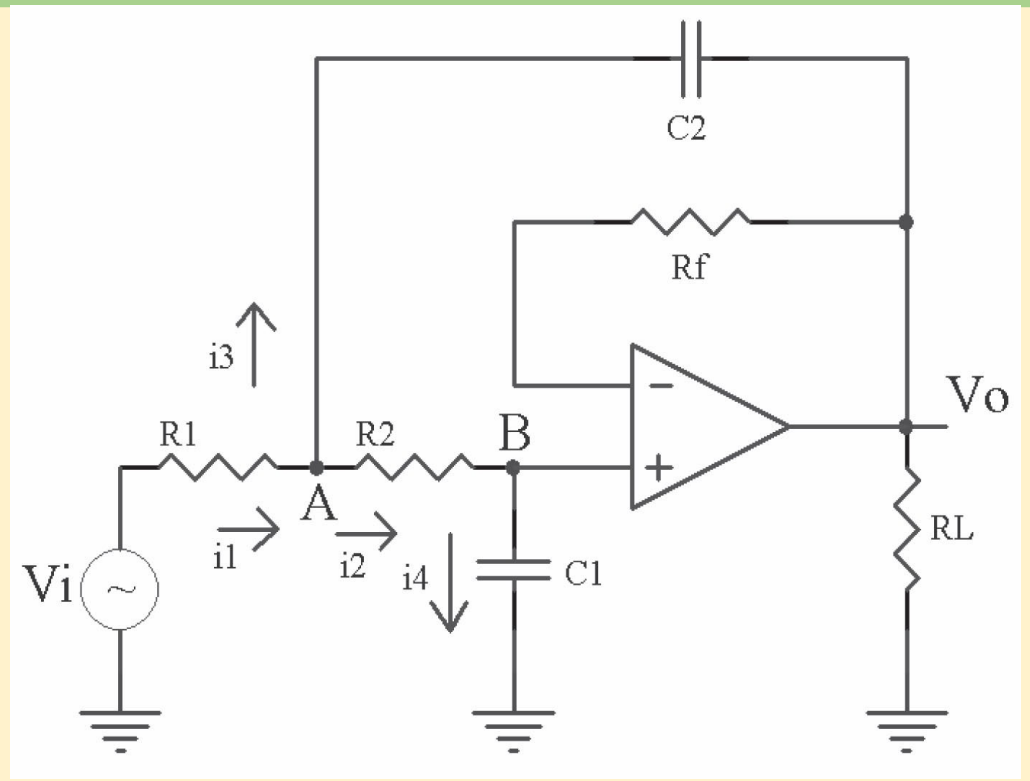


=

Nilai penguatan $\frac{Vo}{Vi}$ dan sudut phase θ untuk beberapa nilai ω yang berbeda adalah

Tabel 6.2 *Nilai penguatan dan sudut phase LPF -40 dB/dec*

No.	Frekuensi (ω)	Penguatan($\frac{Vo}{Vi}$)	Sudut phase (θ)
1	$0{,}1\omega_c$	0,9999500037	–8,13°
2	$0{,}25\omega_c$	0,9980713439	–20,66°
3	$0{,}5\omega_c$	0,9702338206	–43,31°
4	ω_c	$\frac{1}{\sqrt{2}}$ atau 0,707	–90°
5	$2\omega_c$	0,2425528612	–136,69°
6	$4\omega_c$	0,0623794998	–159,34°
7	$10\omega_c$	0,0099995302	–171,87°



Contoh 6.3

Hitunglah frekuensi *cut-off* (ω_c) pada Gambar diatas apabila nilai R1=10K, R2=50K, C1= 10 nF, C2= 100 nF, Rf= 100 K, RL= 10 K!

Penyelesaian: Nilai frekuensi *cut-off* (ω_c) dari LPF –40 dB/dec adalah $\omega_c = \frac{1}{\sqrt{C1.C2.R1.R2}}$

$$\omega_c = \frac{1}{\sqrt{10^{-8}.10^{-7}.10^{4}.5.10^{4}}} = \frac{1}{\sqrt{5.10^{-7}}} = \frac{1}{10^{-4}.\sqrt{50}} = 1414 \text{rad/s}$$

Contoh 6.4

Hitunglah frekuensi *cut-off* (ω_c) pada Gambar 6.2 apabila nilai R1 = R2 = R = 10K, C1 = 10nF, C2 = 2.C1 = 20nF, Rf = 20K, RL = 10K. Apabila $Vi = 100\sin(\omega_c.t + 60^o)mV$, hitunglah Vo pada frekuensi $0{,}1\omega_c$, $0{,}25\omega_c$, $0{,}5\omega_c$, ω_c, $2\omega_c$, $4\omega_c$, $10\omega_c$!

Penyelesaian: Karena nilai R1 = R2 = R dan C2 = 2C1 maka nilai frekuensi *cut-off* (ω_c) dari LPF -40 dB/dec adalah

$$\omega_c = \frac{0{,}707}{C1.R}$$

$$\omega_c = \frac{0{,}707}{C1.R} = \frac{0{,}707}{10^{-8}.10^4} = 7070\text{rad/s} = 7{,}07\text{Krad/s}$$

Untuk $\omega = 0{,}1\omega_c = 707$ rad/s,

$$\frac{Vo}{Vi} = \frac{1}{1-\left(\frac{\omega}{\omega_c}\right)^2 + j\sqrt{2}.\left(\frac{\omega}{\omega_c}\right)} = \frac{1}{1-\left(\frac{0{,}1\omega_c}{\omega_c}\right)^2 + j\sqrt{2}\left(\frac{0{,}1\omega_c}{\omega_c}\right)} = \frac{1}{1-0{,}01+j0{,}1414}$$

$$\left|\frac{Vo}{Vi}\right| = \frac{1}{\sqrt{0{,}99^2+0{,}1414^2}} = \frac{1}{\sqrt{0{,}9801+0{,}02}} = 0{,}999$$

$$\theta = \frac{0^\circ}{tg^{-1}\left(\frac{0{,}1414}{0{,}99}\right)} = \frac{0^\circ}{8{,}13^\circ} = 0^\circ - 8{,}13^\circ = -8{,}13^\circ$$

$$Vo = (0{,}999).100\sin(707.t + 60^\circ + \theta) = 99{,}9\sin(707.t + 51{,}87^\circ)mV$$

Untuk $\omega = 0{,}25\omega_c = 1767{,}5$ rad/s,

$$\frac{Vo}{Vi} = \frac{1}{1-\left(\frac{\omega}{\omega_c}\right)^2 + j\sqrt{2}\left(\frac{\omega}{\omega_c}\right)} = \frac{1}{1-\left(\frac{0{,}25\omega_c}{\omega_c}\right)^2 + j\sqrt{2}\left(\frac{0{,}25\omega_c}{\omega_c}\right)} = \frac{1}{0{,}9375 + j0{,}3535}$$

$$\left|\frac{Vo}{Vi}\right| = \frac{1}{\sqrt{0{,}9375^2 + 0{,}3535^2}} = \frac{1}{\sqrt{0{,}8789 + 0{,}125}} = 0{,}998$$

$$\theta = \frac{0°}{tg^{-1}\left(\frac{0{,}3535}{0{,}9375}\right)} = \frac{0°}{20{,}66°} = 0° - 20{,}66° = -20{,}66°$$

$$Vo = (0{,}998).100\sin(1667{,}5.t + 60° + \theta) = 99{,}8\sin(1767{,}5.t + 39{,}34°)mV$$

Untuk $\omega = 0{,}5\omega_c = 3535$ rad/s,

$$\frac{Vo}{Vi} = \frac{1}{1-\left(\frac{\omega}{\omega_c}\right)^2 + j\sqrt{2}\left(\frac{\omega}{\omega_c}\right)} = \frac{1}{1-\left(\frac{0{,}5\omega_c}{\omega_c}\right)^2 + j\sqrt{2}\left(\frac{0{,}5\omega_c}{\omega_c}\right)} = \frac{1}{1-0{,}25+j0{,}707}$$

$$\left|\frac{Vo}{Vi}\right| = \frac{1}{\sqrt{0{,}75^2+0{,}707^2}} = \frac{1}{\sqrt{0{,}5625+0{,}4998}} = 0{,}97$$

$$\theta = \frac{0^\circ}{tg^{-1}\left(\frac{0{,}707}{0{,}75}\right)} = \frac{0^\circ}{43{,}31^\circ} = 0^\circ - 43{,}31^\circ = -43{,}31^\circ$$

$$Vo = (0{,}97).100\sin(3535.t + 60^\circ + \theta) = 97\sin(3535.t + 16{,}69^\circ)mV$$

Untuk $\omega = \omega_C$,

$$\frac{Vo}{Vi} = \frac{1}{1-\left(\frac{\omega}{\omega_C}\right)^2 + j\sqrt{2}.\left(\frac{\omega}{\omega_C}\right)} = \frac{1}{1-\left(\frac{\omega_C}{\omega_C}\right)^2 + j\sqrt{2}\left(\frac{\omega_C}{\omega_C}\right)} = \frac{1}{1-1+j\sqrt{2}} = \frac{1}{j\sqrt{2}}$$

$$\left|\frac{Vo}{Vi}\right| = \frac{1}{\sqrt{0^2+\sqrt{2}^2}} = \frac{1}{\sqrt{2}} = 0{,}707$$

$$\theta = \frac{0^\circ}{tg^{-1}\left(\frac{\sqrt{2}}{0}\right)} = \frac{0^\circ}{90^\circ} = 0^\circ - 90^\circ = -90^\circ$$

$$Vo = (0{,}707).100\sin(7070.t + 60^\circ + \theta) = 70{,}7\sin(7070.t - 30^\circ)mV$$

Untuk $\omega = 2\omega_c$,

$$\frac{Vo}{Vi} = \frac{1}{1-\left(\frac{\omega}{\omega_c}\right)^2 + j\sqrt{2}.\left(\frac{\omega}{\omega_c}\right)} = \frac{1}{1-\left(\frac{\omega_c}{\omega_c}\right)^2 + j\sqrt{2}\left(\frac{2\omega_c}{\omega_c}\right)} = \frac{1}{-3+j2{,}828}$$

$$\left|\frac{Vo}{Vi}\right| = \frac{1}{\sqrt{(-3)^2 + 2{,}828^2}} = \frac{1}{\sqrt{9+7{,}9976}} = 0{,}24$$

$$\theta = \frac{0°}{tg^{-1}\left(\frac{2{,}828}{-3}\right)} = \frac{0°}{136{,}69°} = 0° - 136{,}69° = -136{,}69°$$

$$Vo = (0{,}24).100\sin(14140.t + 60° + \theta) = 24\sin(14140.t - 76{,}69°)mV$$

Untuk $\omega = 4\omega_c = 28280 \text{rad/s}$,

$$\frac{Vo}{Vi} = \frac{1}{1-\left(\frac{\omega}{\omega_c}\right)^2 + j\sqrt{2}.\left(\frac{\omega}{\omega_c}\right)} = \frac{1}{1-\left(\frac{4\omega_c}{\omega_c}\right)^2 + j\sqrt{2}\left(\frac{4\omega_c}{\omega_c}\right)} = \frac{1}{1-16+j5{,}656}$$

$$\left|\frac{Vo}{Vi}\right| = \frac{1}{\sqrt{(-15)^2 + 5{,}656^2}} = \frac{1}{\sqrt{225+31{,}99}} = 0{,}06$$

$$\theta = \frac{0°}{tg^{-1}\left(\frac{5{,}656}{-15}\right)} = \frac{0°}{159{,}34°} = 0° - 159{,}34° = -159{,}34°$$

$$Vo = (0{,}06).100\sin(28280.t + 60° + \theta) = 6\sin(28280.t - 99{,}34°)mV$$

Untuk $\omega = 10\omega_c = 70700 \text{rad/s}$,

$$\frac{Vo}{Vi} = \frac{1}{1-\left(\frac{\omega}{\omega_c}\right)^2 + j\sqrt{2}\left(\frac{\omega}{\omega_c}\right)} = \frac{1}{1-\left(\frac{10\omega_c}{\omega_c}\right)^2 + j\sqrt{2}\left(\frac{10\omega_c}{\omega_c}\right)} = \frac{1}{1-100+j1,414}$$

$$\left|\frac{Vo}{Vi}\right| = \frac{1}{\sqrt{(-99)^2 + 14,14^2}} = \frac{1}{\sqrt{9801 + 199,9396}} = 0,009$$

$$\theta = \frac{0°}{tg^{-1}\left(\frac{14,14}{-99}\right)} = \frac{0°}{171,87°} = 0° - 171,87° = -171,87°$$

$$Vo = (0,009).100\sin(70700.t + 60° + \theta) = 0,9\sin(70700.t - 111,87°)mV$$

Langkah-langkah perancangan LPF - 40 dB/decade

1. Pilihlah frekuensi *cut-off* () atau f_c,
2. Pilihlah **R1 = R2 = R** antara 10 K dan 100 K,
3. Hitunglah **C1** dengan rumus **C1 =**
4. Pilihlah **C2 = 2.C1**
5. Pilihlah **Rf = 2.R**

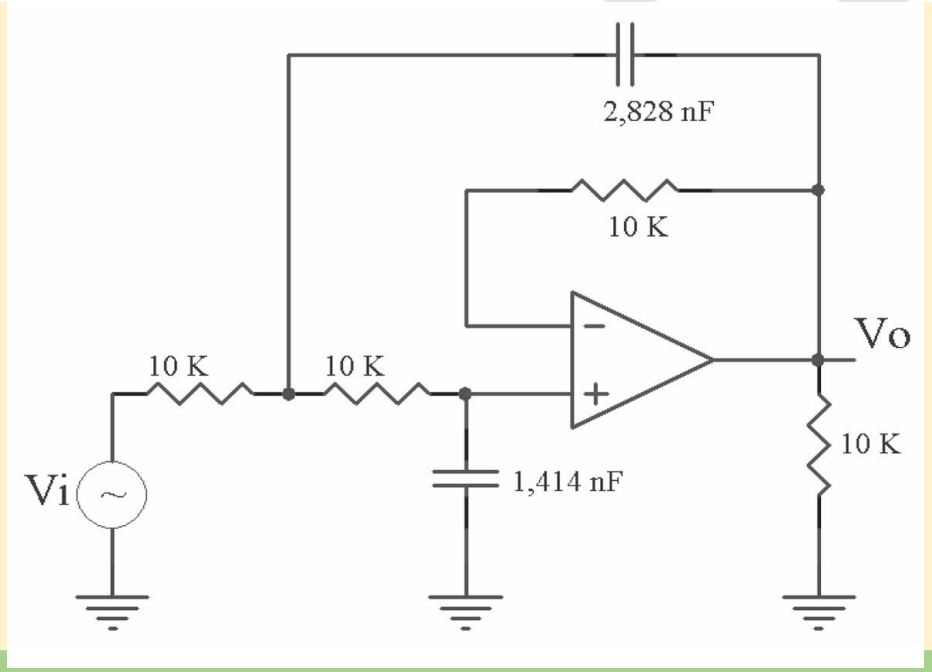
Contoh 6.5

Rancanglah LPF -40 dB/dec dengan $\omega_c = 50krad/det$!

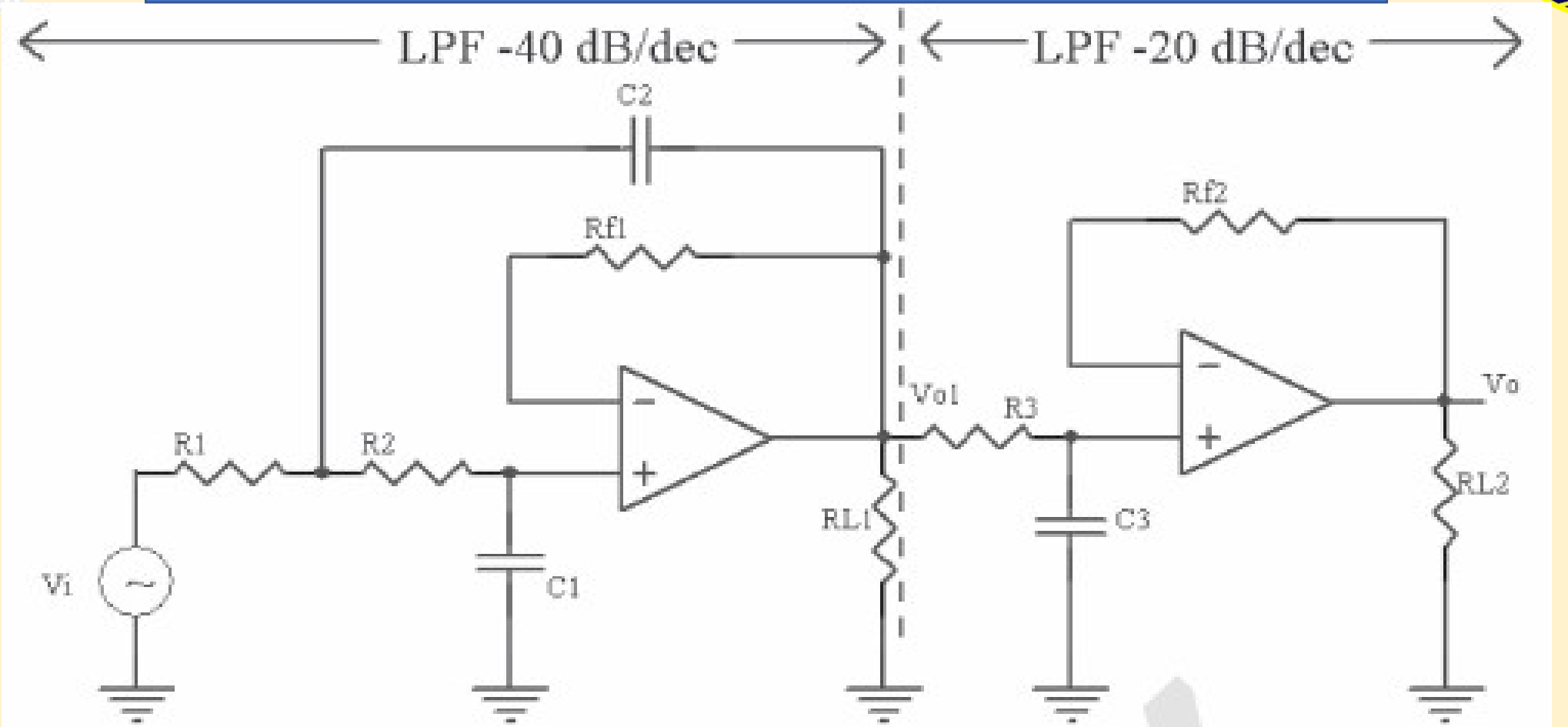
Penyelesaian:

1. Dipilih frekuensi cut-off $\omega_c = 50krad/det$
2. Dipilih R1 = R2 = R = 10 K
3. Dihitung C1 yaitu $C1 = \frac{0,707}{\omega_c.R} = \frac{0,707}{5.10^4.10^4} = 1,414.10^{-9}F = 1,414nF$
4. Pilihlah C2 = 2.C1 yaitu C2 = 2,828 nF
5. Pilihlah Rf = 20 K.

Gambar rangkaian LPF -40 dB/dec dengan $\omega_c = 50krad/det$.



Rangkaian LPF - 60 dB



Gambar 6.3 *Rangkaian LPF -60 dB/decade*

Analisis dari rangkaian filter LPF -60 dB/dec bahwa penguatan keseluruhan dari rangkaian adalah

=

=

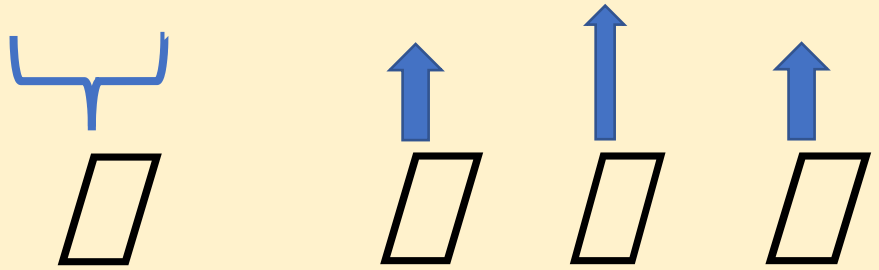
Pada LPF -60 dB/dec bahwa pada frekuensi maka nilai penguatan

= = **0,707** dan sudut phasenya sebesar –135^{o}. Apabila nilai R1=R2=R3=R,C1=0,5.C3, C2=2.C3 maka besarnya frekuensi =

cut-off

=

=



Contoh 6.6

Hitunglah frekuensi *cut-off* () pada Gambar 6.3 apabila nilai R1=R2=R3=R=10K, C3=20 nF, C1=0,5.C3=10 nF, C2=2.C3=40 nF, Rf=10K, RL=10K!

Apabila V*i* =100sin(.t+60^{o})*mV,* hitunglah Vo pada frekuensi 0,1 , 0,25 , 0,5 , , 2 , 4 , 10 !

Penyelesaian:

Karena nilai R1=R2=R3=R=10 K dan C3=20 nF, C1=0,5C3, C2=2C3 maka nilai frekuensi *cut-off* () dari LPF -60 dB/dec adalah

Vi = 100 sin(500.t+60º)

= =

=

$$\left|\frac{V\square}{Vi}\right\rangle \text{¿}\frac{1}{\sqrt{(0,99)2+(0,1)2}}\square\frac{1}{\sqrt{(1)2+(0,1)2}}=1$$

o

o

Vo = (1)100sin(500.t+60º+) =

100sin(500.t+θ) mV

Vi = 100 sin(1250.t + 60º)

= =

=

$$\left|\frac{V_o}{V_i}\right| = \frac{1}{\sqrt{(0,94)^2+(0,25)^2}} \cdot \frac{1}{\sqrt{(1)^2+(0,25)^2}} = 0,997$$

Vo = (0,997)100sin(1250.t+60º+) =

0,997sin(1250.t+º) *mV*

Vi = 100 sin(2500.t + 60º)

= =

=

$$\left|\frac{V_o}{V_i}\right| = \frac{1}{\sqrt{(0{,}75)^2+(0{,}5)^2}} \cdot \frac{1}{\sqrt{(1)^2+(0{,}5)^2}} = 0{,}993$$

Vo = (0,993)100sin(2500.t+60º+) =

0,993sin(2500.t+0,17º) *mV*

Vi = 100 sin(5000.t + 60º)

= =

=

$$\left|\frac{V\square}{Vi}\right| \vee ¿ \frac{1}{\sqrt{(0)2+(1)2}} \square \frac{1}{\sqrt{(1)2+(1)2}} = 0,707$$

o

o

Vo = (0,707)100sin(5000.t+60º+) = 70,7 sin(5000.t+75º) *mV*

Vi = 100 sin(10K.t + 60º)

= =

=

$$\left|\frac{V\square}{Vi}\right| \vee ¿ \frac{1}{\sqrt{(-3)2+(2)2}} \square \frac{1}{\sqrt{(1)2+(2)2}} = 0,124$$

o

o

Vo = (0,124)100sin(10K.t+60º+) = 12,4 sin(10K.t

151º) *mV*

Vi = 100 sin(20K.t + 60º)

= =

=

$$\left|\frac{V\square}{Vi}\right| \vee ¿ \frac{1}{\sqrt{(-15)2+(4)2}} \square \frac{1}{\sqrt{(1)2+(4)2}} = 0,016$$

o

o

Vo = (0,016)100sin(20K.t+60º+) = 1,6 sin(20K.t 181º) *mV*

Vi = 100 sin(50K.t + 60º)

= =

=

$$\left|\frac{V\square}{Vi}\right| \vee ¿ \frac{1}{\sqrt{(-99)2+(10)2}} \square \frac{1}{\sqrt{(1)2+(10)2}} = 0,001$$

o

o

Vo = (0,001)100sin(50K.t+60º+) = 0,1 sin(50K.t 198,52º) *mV*

Langkah-langkah perancangan LPF - 60 dB/decade

1. Pilihlah frekuensi *cut-off* () atau f_c,
2. Pilihlah **R1 = R2 = R3 = R** antara 10 K dan 100 K,
3. Hitunglah **C3** dengan rumus **C3 =**
4. Pilihlah **C1 = 0,5.C3**
5. Pilihlah **C2 = 2.C3**
6. Pilihlah **Rf1 = 2.R**; **Rf2 = R**

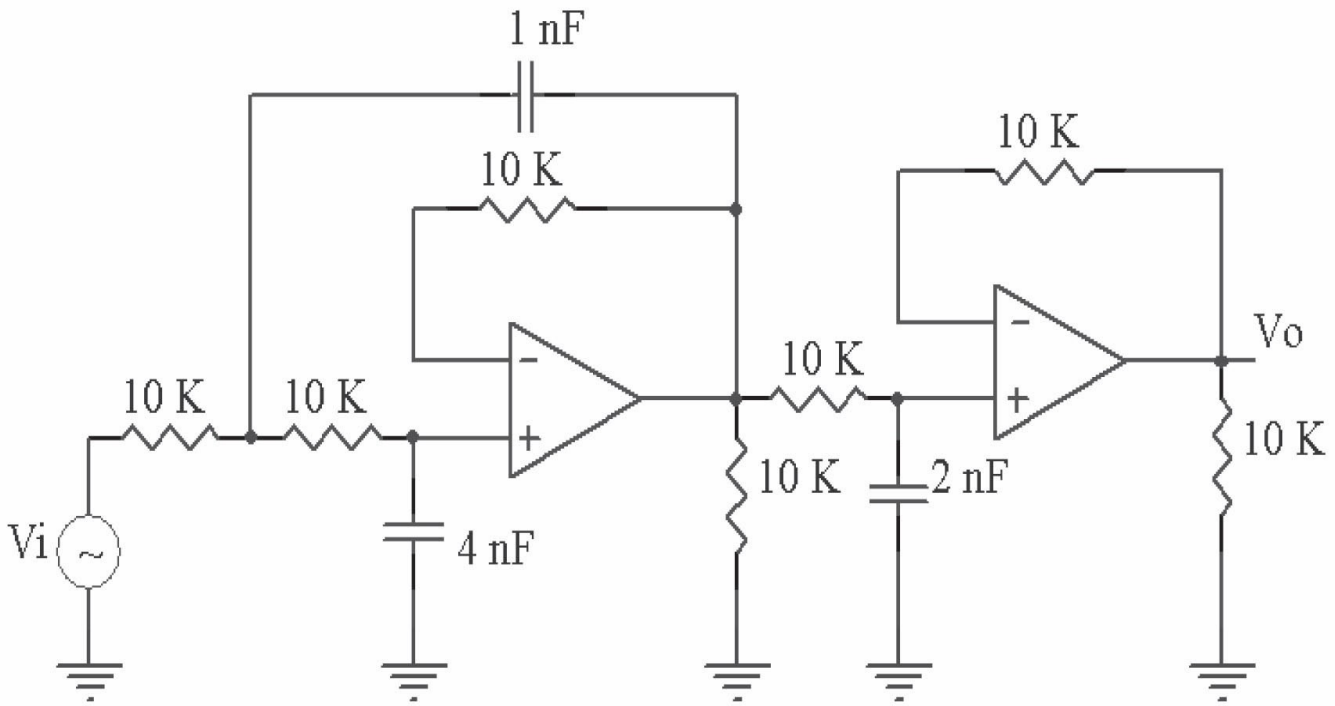
Contoh 6.7

Rancanglah LPF-60dB/dec dengan $\omega_c = 50krad/det$!

Penyelesaian:

1. Dipilih frekuensi *cut-off* $\omega_c = 50krad/det$
2. Dipilih R1 = R2 = R3 = 10 K
3. Dihitung C3 yaitu $C3 = \frac{1}{\omega_c . R} = \frac{1}{5.10^4 . 10^4} = 2.10^{-9} F = 2nF$
4. Pilihlah C1 = 2. C3 yaitu C1 = 4 nF
5. Pilihlah C2 = 0,5 . C3 = 1 nF
6. Pilihlah Rf1 = Rf2 = R = 10 K.

   Rangkaian LPF -60 dB/dec dengan $\omega_c = 50krad/det$.



https://www.its.ac.id/telektro/id/beranda/